AD-A126 550 A FIBER-OPTIC LINK FOR USE WITH MICROWAVE FIELD SENSORS 1/1
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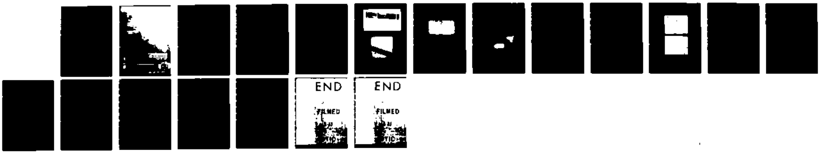

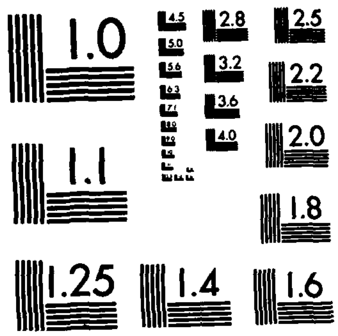

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The paper describes two types of compact fiber-optic links designed to provide dielectric isolation and noise immunity to the interconnection of subminiature microwave field-sensor probes and remotely located test equipment. The system measures the microwave signal levels leaking into partially shielded electronic packages. The fast-rise link (rise time <3 ns) is for use where the microwave irradiation source produces radar-like short pulses. The high-sensitivity link (input noise level <3 µV) is for use with laboratory 1-kHz modulated microwave sources. The transmitters are the size of a gum eraser, 1 1/4 × 1 1/4 × 2 3/8 in. The 15-V dc power for the transmitters is obtained either from the system under test or a small NiCd battery.

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CONTENTS

FIGURES

1. INTRODUCTION

The fiber-optic signal links described here were built as a part of a system which measures microwave leakage into electronic packages with the purpose of determining those levels which produce upset or damage. The rf levels are sensed by a subminiature rf probe and crystal detector which is described elsewhere.* The extremely small size of this probe allows determination of the field in a highly localized area. Fiber optics was chosen as the method of connecting the probe's output to external equipment in order to avoid the undesirable effects of conducting cables. Conductors may pick up extraneous electromagnetic noise, especially in the case of small microwave levels at the detector, where the signal output may be measured in microvolts; conductors also alter the microwave fields in the vicinity where they penetrate the electronics enclosures.

2. FAST-RESPONSE LINK

The optical signal transmission system shown in figure 1 is intended for use with pulse-modulated microwave sources and was accordingly designed for a rise time <3 ns and to have negligible droop at tens of microseconds. The unipolar signal level from the probe ranges from about 1 mV to several tens of millivolts, setting the sensitivity requirement for the fiber-optic transmitter. A prime requirement for the transmitter was that it be of small size so that both it and the detector could be placed in confined areas. Figure 2 shows that the transmitter is the size of a gum eraser, about 1-1/4 × 1-1/4 × 2-3/8 in. The power supply is external, in many cases supplied by the equipment under test. There were no size requirements upon the receiver except that it fit a standard rack.

Two fibers can be seen leaving the transmitter (see fig. 2, right side of case). These attach to the two optical connectors on the front panel of the receiver. One of the fibers carries the analog signal from the transmitter to receiver and the other control signals from the controller (in the receiver box) to the transmitter. Both fibers are 100-μm-core step-index fibers which are inexpensive, readily available, and compatible with all-plastic connectors. All-plastic connectors must be used because it is not permissible to have metallic connectors near the object being tested. Fiber "extension cords" up to thousands of feet in length may be inserted as desired.

2.1 Transmitter

The transmitter contains two circuit boards, each 1 × 2-1/4 in., mounted one on top of the other. One board amplifies the input signal and applies it to the light-emitting diode (LED), thus producing the analog optical signal. The second board contains a calibration pulse generator, a voltage regulator, a battery condition sensor, and a command receiver.

*R. V. Garver, *Interim (6 month) Report for the Directed Microwave-Energy Vulnerability Program. To be published.* HDL-PRL

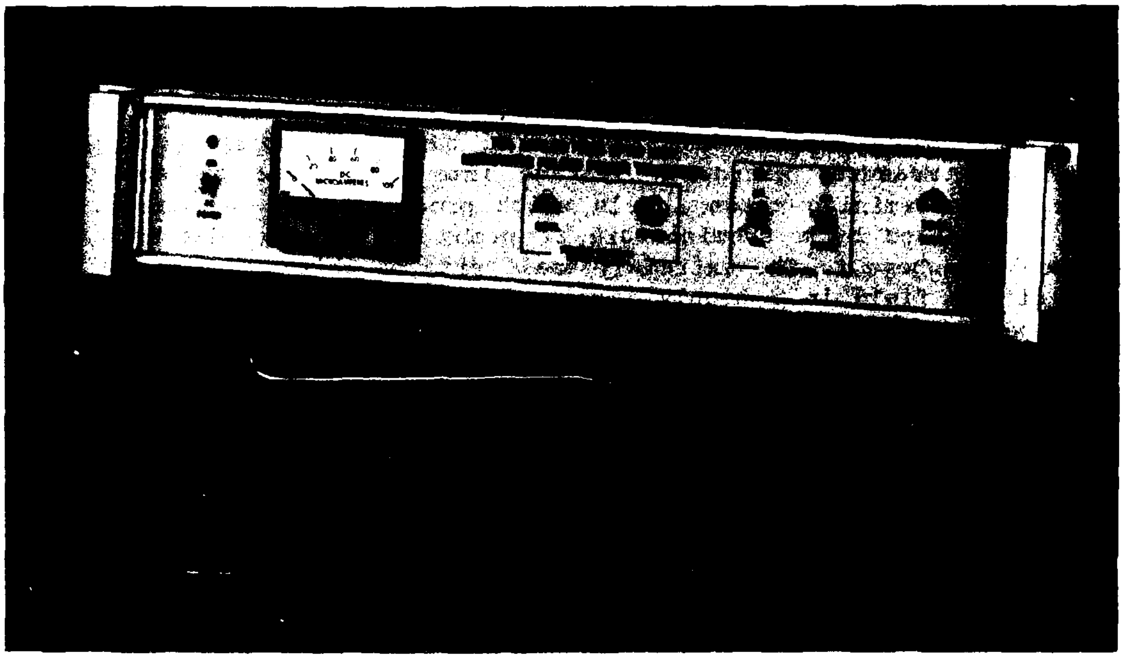

Figure 1. Optical transmitter and receiver.

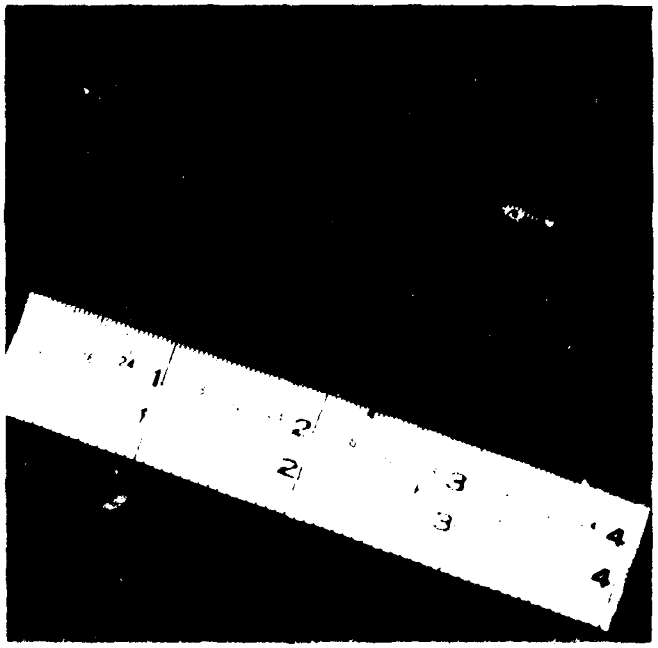

Figure 2. Close-up view of optical transmitter.

The transmitter board is shown in detail in figure 3 and its circuit in figure 4. An unusual construction is used, with the larger semiconductors fastened into shallow wells in the circuit board with their leads upward. Small components are soldered directly between these leads. The lead lengths are quite short and therefore rigid; the finished circuit is sturdy and accessible for repair or adjustment. This arrangement allowed a closer spacing of components and shorter lead lengths than seemed attainable with a more conventional printed circuit board. Silver epoxy is used to form a good ground between semiconductor cases and the ground plane of the board.

Figure 3. Photo of fast-response transmitter board. Large brass cylinder is LED, left of it is driver Q1. Amplifiers A1 and A2 are upper center.

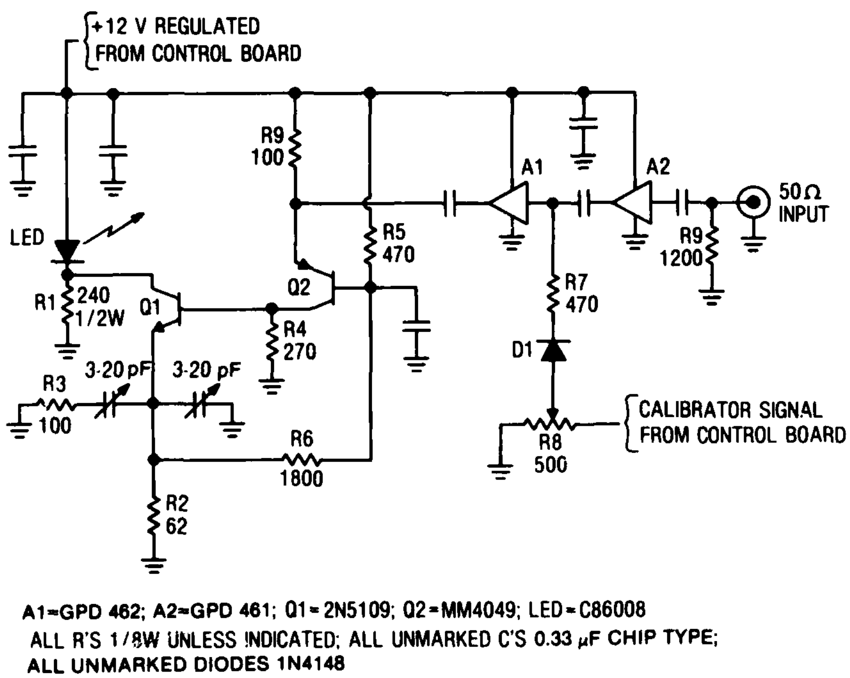

Figure 4. Schematic of fast-response transmitter.

The transmitter circuit is based on that of a previous system;[1] it is straightforward and requires little comment. R1 supplies a dc bias to the LED in addition to the steady-state current through Q1. D1, R7, and R8 provide the means of injecting the calibrator signal into the transmitter. When the calibrator is off, D1 is reverse biased and has little effect on the circuit. When the calibrator is operating, the diode is forward biased and conducts.

The controller board is shown in figure 5 and its circuitry in figure 6. IC3 section 1 (IC3-1) amplifies the output of photodetector Q4. If Q4 is dark, the output of IC3-1 is low and IC3 sections 2-4 are unbiased and therefore inoperative (and drawing no current). When Q4 is illuminated, sections 2-3 are biased on by the current through R7 and begin to function. Most important, IC5, Q4, and IC3-2 supply a regulated 12 V to the transmitter, thus causing it to operate. If Q4 is steadily illuminated, this is all that happens, and the transmitter turns on. If, however, the illumination falling on Q4 is periodically interrupted, C1 and R7 maintain the bias on IC3-2-4; yet D2, R6, and C2 provide a zero to IC3-4; this causes Q3 to turn on, thus enabling the calibration generator IC2. The frequency of the square wave produced by IC2 depends on the voltage applied to its pin 2. If the battery voltage sensed by IC3-3 is below normal, its output goes high and increases the repetition rate of IC2 to about five times its normal value; this signals the low-voltage condition to the user.

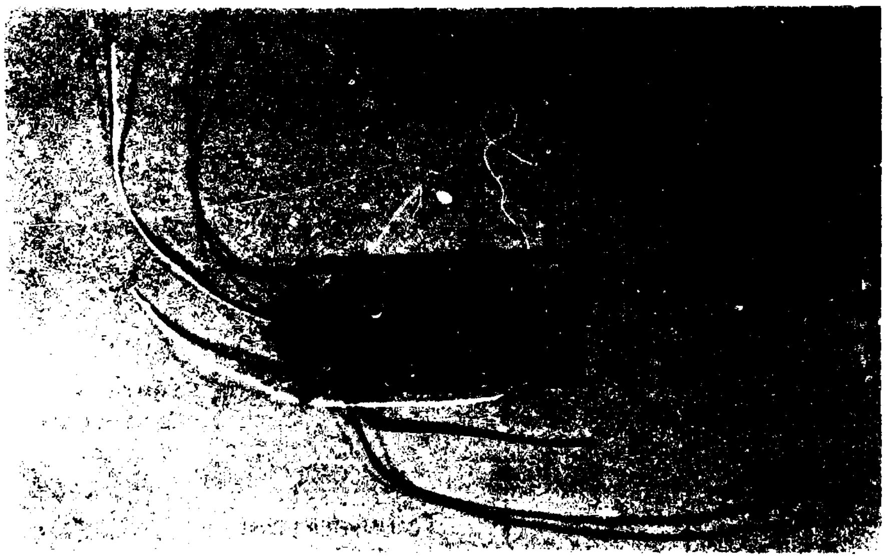

Figure 5. Photo of control/calibrator/regulator board for transmitter.

[1]J. C. Blackburn and R. Martin, *A Versatile Fiber-Optic Signal Link for EMP Testing and General Laboratory Application*, Harry Diamond Laboratories, HDL-TM-80-5 (June 1980).

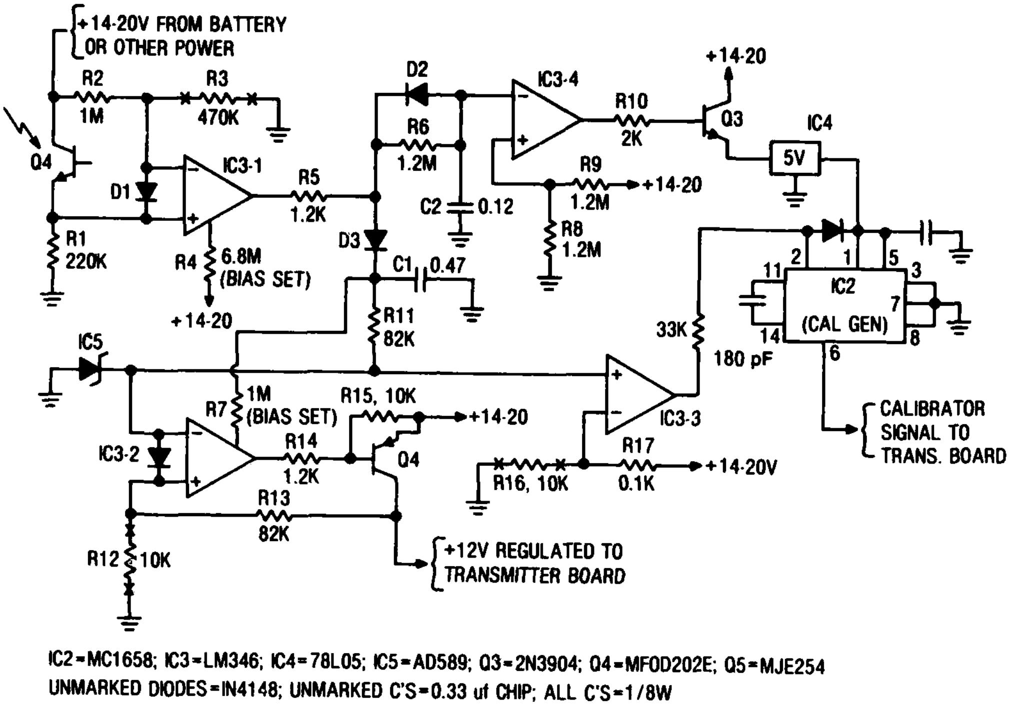

Figure 6. Schematic of control/calibrator/regulator board.

R2-R3, R12-R13, and R16-R17 are voltage dividers that set, respectively, optical sensitivity, regulator level, and low battery warning level. Instead of using potentiometers, which are bulky and subject to unauthorized tweaking, R3, R12, and R16 are connected by tiny component lead sockets. The appropriate value is found by temporary insertion of an external potentiometer, and the closest value of 1/8-W resistor is then inserted into the board.

The standby current consumption of the transmitter is small, less than 100 μA. The operating current is about 110 mA (at 12 V) during signal transmission, and an additional 30 mA is required while the 1.5-MHz square-wave calibrator is operating.

No power source is contained in the transmitter. Since a voltage regulator is incorporated in the circuit, the external voltage supply can range between about 13 and 25 V. In some test situations the transmitter is operated from the internal power of the system under test. Where this is not possible, the external NiCd battery supplied with the transmitter is adequate for about two hours of operation. The power input line to the transmitter is filtered and bypassed to prevent noise from entering the transmitter case and circuits.

2.2 Receiver-Controller

Figure 7 shows the optical receiver circuitry. Q7, D1, IC8, and associated circuitry form a constant current source which causes the voltage on the avalanche photodiode (APD) to adjust to a value which provides a fixed current. This action compensates for both temperature effects on the APD and variations in the optical signal. Q6, IC6-1, and so on, form a voltage limiter, so that even in the absence of an optical signal the APD will not be driven to breakdown (self avalanche). A silicon diode, part of the detector module and connected between ground and module pin 8, corrects the voltage limit for ambient temperature. IC6-2 drives the indicating meter in proportion to the bias voltage on the APD; a higher reading indicates a lesser optical signal.

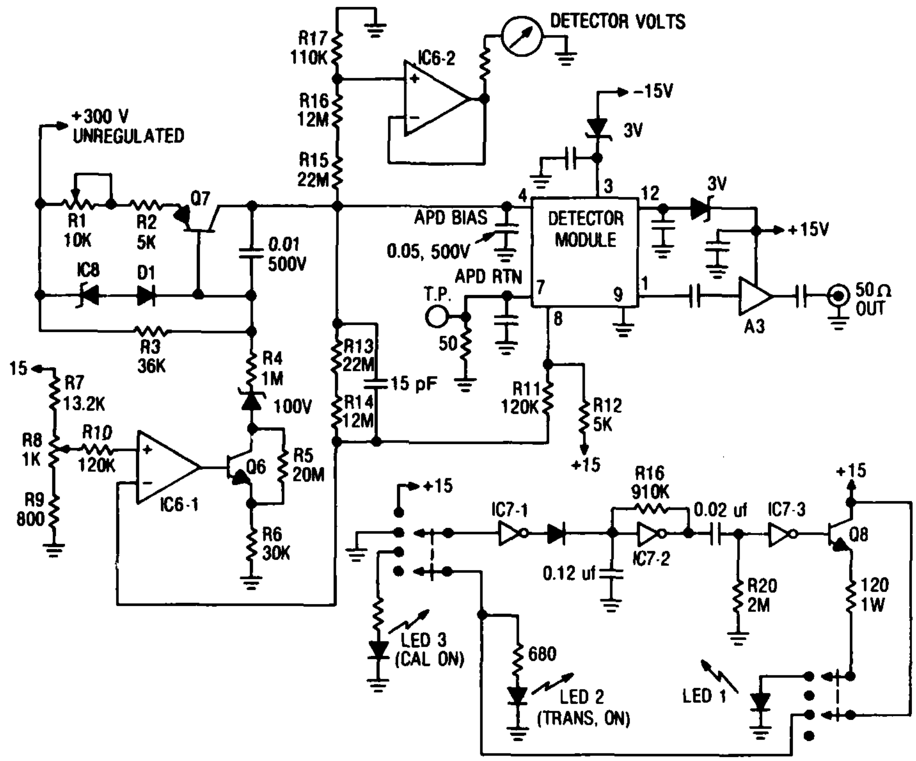

Figure 7. Schematic of optical receiver and control.

IC7-2 and associated components form a 10-Hz oscillator whose output is differentiated, inverted by IC7-3, and applied to Q8. Q8 drives the control signal LED (LED-1) with either a steady dc current (switch in lower position) or a waveform of 90 percent on, 10 percent off, with a pulse repetition rate of 10 Hz (switch in upper position). The steady current causes the remote transmitter to turn on; the pulsed current causes both turn-on and calibrator operation.

Figure 8 compares the microwave detector signal as transmitted by both coaxial cable and the optical link. The two waveforms match to well within 1 dB when the calibration of the optical link is taken into account.

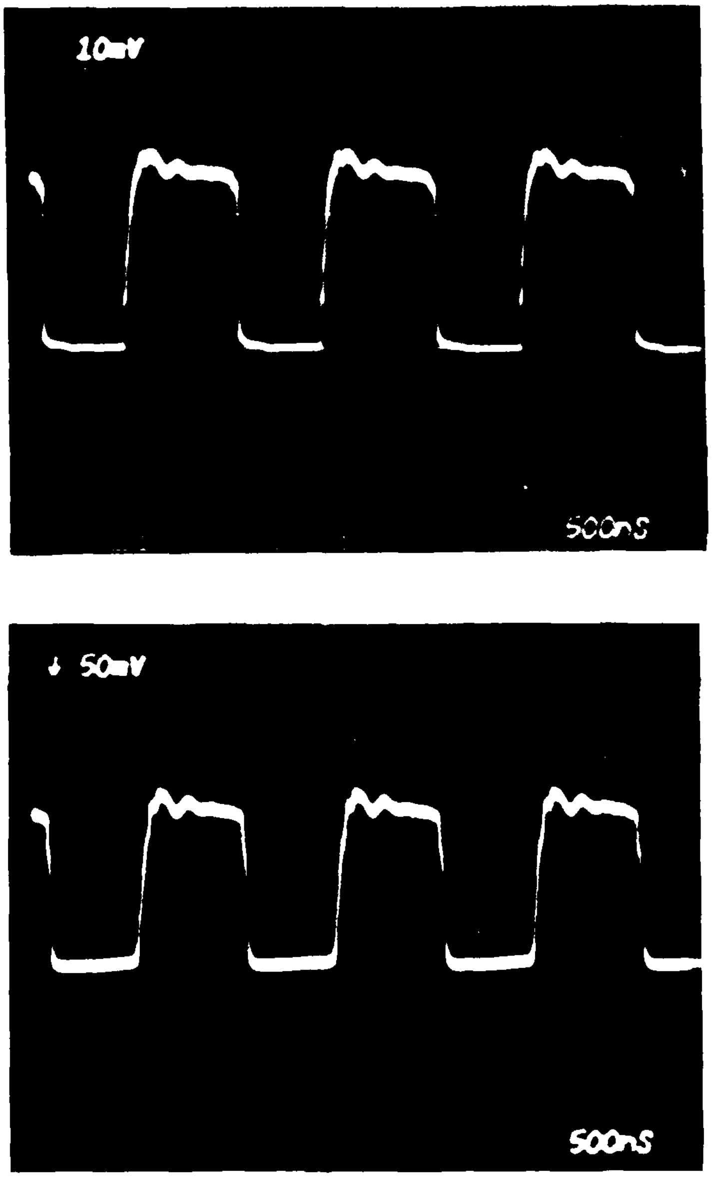

Figure 8. Comparison of microwave detector signal as carried by coaxial cable (top) and as carried by fast-response optical link (bottom). Test performed in arrangement where presence of conducting coaxial cable was noninterfering.

3. HIGH-SENSITIVITY LINK

It was found necessary to provide an optical link for transmission of the low-level 1-kHz signals produced by the field sensors when the irradiation source was relatively low-power laboratory signal generators (rather than a high-power radar transmitter). In order to expedite construction, one of the high-speed links was modified, keeping as much of the original circuitry as possible.

The control board (fig. 5 and 6) was unchanged except for altering the value of R12 to provide a 9-V output and the value of the timing capacitor on IC2 to produce a 1-kHz square-wave output.

The receiver (fig. 7) was modified by taking the signal output directly from pin 1 of the detector module and eliminating A3.

The transmitter required extensive changes: A1, A2, Q1, and Q2 (fig. 4) were removed, although the circuit board (fig. 3) was saved. The circuitry of figure 9 was then installed. The LM 381 was epoxied (pins up) at the location of A1, A2 in the original circuit. The 2N2905 was located in the heat sink which held Q1 in the high-speed link. Point-to-point wiring, as in figure 3, was used.

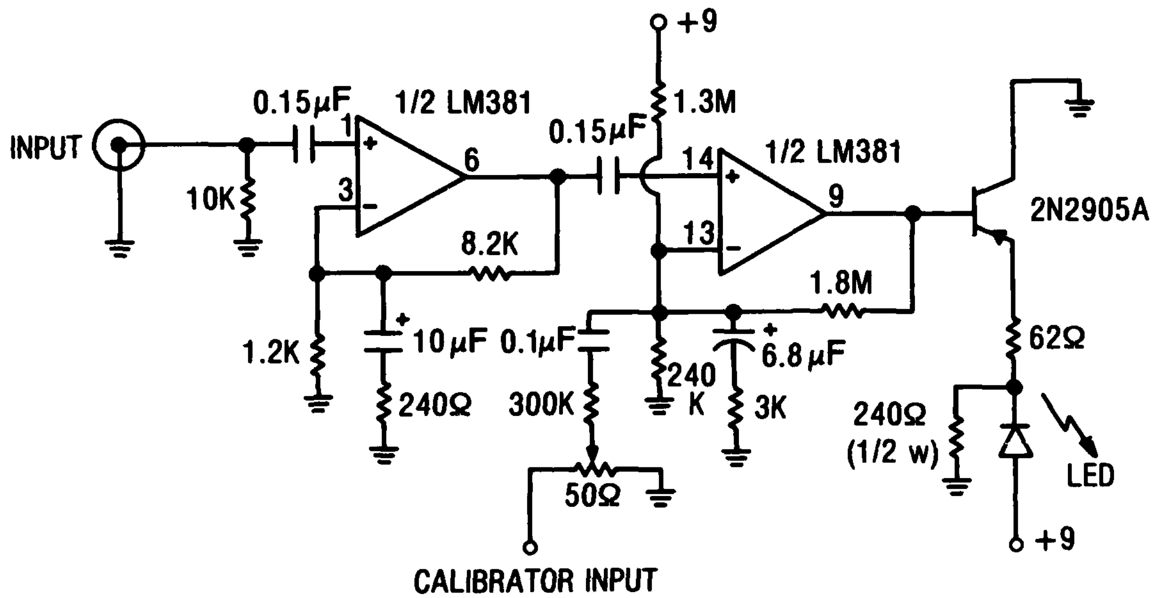

Figure 9. Schematic of high-sensitivity 1-kHz transmitter.

To reduce the noise level at the input, one of the two transistors in the differential first stage was disabled, and the signal and feedback were applied to the base and emitter, respectively, of the remaining transistor. The noise level at the receiver output corresponds to about 3 μV at the input to the transmitter (over a bandwidth of 10 Hz to 10 kHz); gain from input to output is about 55 dB. The maximum linear input is about 350 μV. If a tuned detector, such as a Hewlett Packard 3410 microvolt meter, is placed at the receiver, input signal levels on the order of 0.1 μV can be measured.

4. CONCLUDING REMARKS

The simple circuits in the transmitter could obviously be hybridized, resulting in an even smaller package. The present configuration did meet all needs of the experiment and was relatively quick and economical to build. A single-fiber connection scheme was considered in which the signal LED (LED 1 of fig. 4) would serve as a detector for control commands before being biased "on" for transmission. This would have the desirable result of saving one interconnecting fiber-optic cable, but would increase the size of the control circuitry somewhat; such a scheme would also require several mechanical and optical components in the fiber-to-detector path in order to switch the fiber between the function of carrying control signals from receiver to transmitter and that of carrying data from transmitter to receiver. This single-fiber approach was not implemented in this system because the difficulties associated with a second (control) fiber were minor. Where long fiber runs are needed, or access for laying cables is limited, the single fiber might have considerable advantage.

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